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# SIGNAL-CONTROLLED RESPONDING

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Pigeons' key pecks were reinforced with grain, then extinguished. An 8-second tone preceded the availability of peck-dependent grain 1 second after tone offset. When a tone signalled grain and an 8-second clicking sound did not, three pigeons pecked during a high percentage of tone periods, but they pecked during a low percentage of click periods. When the roles of the tone and clicking sound were reversed, performance reversed. For other birds, when a key peck during the tone cancelled the availability of grain (omission procedure), the tendency to key peck during the tone decreased some, but still remained high. A third group of pigeons received the omission procedure with the addition that the tone could not end unless 2 seconds had elapsed without a key peck. The pigeons continued to respond in a high percentage of tone periods. The experiments favor an explanation based on the pairing of the tone with a reinforced response, such as Pavlovian conditioning.

*Key words:* stimulus control, automaintenance, Pavlovian conditioning, key pecking, pigeons

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Lewis, Lewin, Muehleisen, and Stoyak (1974) reported an incidental observation that is the focus of this report. In that experiment, pigeons were trained on two procedures. One was a standard variable-interval (VI) schedule; the other was similar except that a 5-sec tone preceded each opportunity to produce grain. The purpose of the experiment was to determine which of the two procedures would be selected when either was available. The results showed that subjects chose the signalled procedure.

The pattern of key pecking in the signalled condition was unexpected. Each pigeon consistently pecked during the tone preceding the opportunity to produce grain, although key pecks were never reinforced in the presence of the tone.

The present study addressed three general explanations of the tone's control. One explanation involved pseudoconditioning; that is, pigeons may tend to key peck during auditory signals whether or not the signals are related to grain availability. Experiment I tested this pseudoconditioning explanation with the presentation of two stimuli, one auditory signal paired with the opportunity to receive grain (conditioned stimulus or CS+) and a different auditory signal following which no grain ever occurred (CS−). Then, the stimuli serving as the CS+ and CS− were switched.

The second explanation was that key pecking during the tone may have resulted in more rapid delivery of grain immediately after the tone, since the pigeon was positioned in front of the key at the tone's offset. This notion could be called an accidental-reinforcement account, because pecking during the tone was not required, but could have been accidentally reinforced. Experiment II tested this accidental-reinforcement hypothesis. A reinforcement-omission procedure was used in which a key peck during the CS cancelled the availability of grain after CS offset. In this procedure, key pecks during the CS explicitly prevented grain.

A third explanation focused on the role of the tone's offset. Key pecking during the tone could have been occasionally reinforced by offset of the tone, which was occasionally associated with grain. By this account, the offset of the tone acted as a conditioned reinforcer for key pecks during the tone. Experiment III tested this conditioned-reinforcer hypothesis. Again, an omission procedure was used, but

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this time a no-response criterion for CS termination eliminated any fortuitous contingency between key pecks and CS offset.

In each of the present experiments, when grain was available it was delayed for 1 sec after CS offset. The purpose of this procedure was to ensure a delay between pecks during the CS and reinforcement and to minimize the reinforcer's direct strengthening effect on key pecks during the CS.

## EXPERIMENT I

### METHOD

*Subjects*

Four experimentally naive White Carneaux pigeons, obtained from Palmetto Pigeon Plant, Sumter, South Carolina, were reduced to between 75% and 80% of their free-feeding weights; fresh water and grit were available at all times in the home cage.

*Apparatus*

A BRS-LVE pigeon test chamber measuring 45 cm long, 35 cm wide, and 36 cm high was used. Two response keys 2 cm in diameter, requiring approximately 0.10 N to depress, were mounted one above the other in the center of the front panel. The bottom key, which could be illuminated red or white, was centered 20 cm from the chamber floor; the top key (used in Experiment II), which could be illuminated white, was centered 4.5 cm above the bottom one. A peck on the bottom key produced a click from a relay mounted behind the front panel. Also mounted behind the front panel were a Mallory Sonalert that produced a 2800-Hz, 70-dB tone and a speaker that produced a steady 7-Hz, 70-dB clicking sound (reference 20 $\mu N/m^2$, scale C); these stimuli served as the CSs. The grain hopper was in the lower-left corner of the front panel. General illumination was provided by two CM #313 lamps mounted near the chamber ceiling. These lamps were turned off when the grain hopper was up, but were on at all other times. White noise and a ventilating fan masked extraneous sounds. Onset of the white noise signalled the start of a session; offset signalled the end of a session. Solid-state programming equipment in a room adjacent to the chamber provided experimental events.

*Procedure*

Subjects were tested daily in sessions that lasted until 31 reinforcers, 4 sec access to grain, were delivered. Each session was about an hour long.

*Key-peck training and extinction.* The bottom key was continuously illuminated red, and the pigeons were trained to peck it by the method of successive approximations. After key pecking was established, each pigeon was tested for two days on each of the following schedules of reinforcement: continuous reinforcement (each peck was reinforced), VI 5-sec, VI 15-sec, and VI 30-sec. All pigeons were then given two extinction sessions, during which key pecks had no scheduled effect.

*Response-independent grain.* Both the CS+ and CS− occurred at varying intervals ranging from 9 sec to 330 sec, with a mean interval length of 90 sec (variable time, or VT 90-sec); CS+ and CS− were 8 sec. The CS− never occurred within 8 sec before the CS+ or within 30 sec after a grain presentation. One second after the CS+, grain was presented independent of behavior. For Pigeons 1664, 3659, and 5704, the CS+ was the tone, and the CS− was the clicking sound throughout all sessions of this procedure. For Pigeon 4117, which received only this procedure, the CS+ was the tone, and the CS− was the clicking sound for the first series of sessions; the CS+ was the clicking sound, and the CS− was the tone for the second series of sessions.

*Response-dependent grain.* After five to six sessions of response-independent grain, Pigeons 1664, 3659, and 5704 received response-dependent grain. At first, the CS+ was the tone, and the CS− was the clicking sound; later, the CS+ was the clicking sound, and the CS− was the tone. Grain did not occur automatically 1 sec after CS+ offset; a single key peck 1 sec more after CS+ offset was required to produce grain.

### RESULTS

Sessions were divided into CS+, CS−, and control periods. The CS+ and CS− periods were 8 sec in duration, control periods were 9 sec. The first control period began at the start of the session, and control periods continued to be recorded until the first CS. Following the CS and the grain presentation, if one were scheduled, control periods were again recorded until the next CS. The dependent variable was the percentages of CS+, CS−, and control periods in which at least a single key peck occurred (per cent periods with a peck). Absolute response rates in each of the three periods were also recorded.

For three of the four pigeons, the percentage of periods with a peck fell quickly to zero in

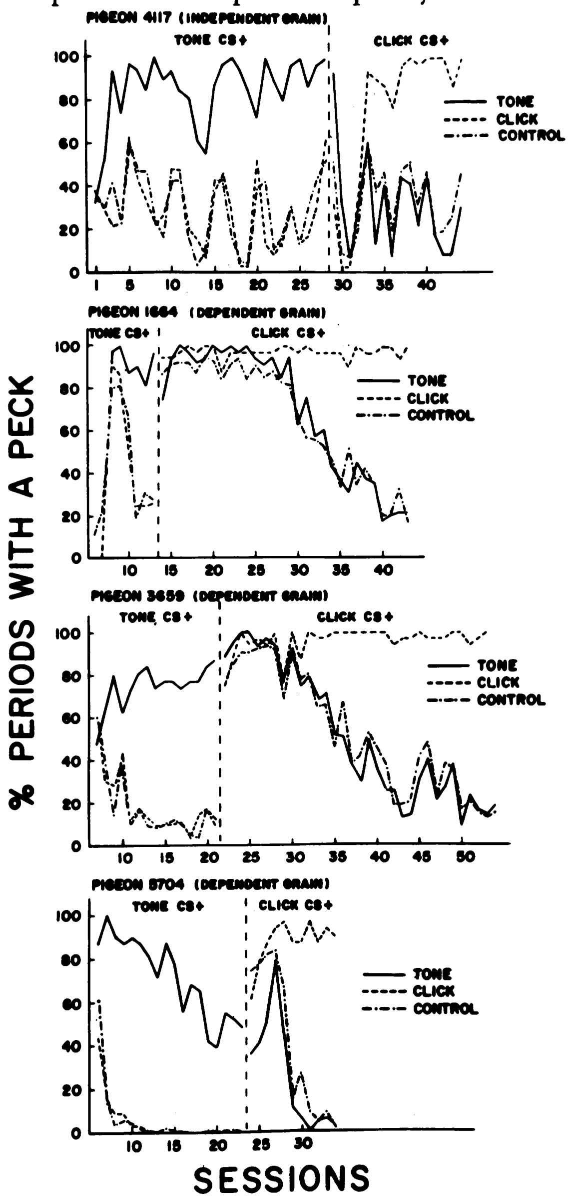


Fig. 1. Per cent periods with a peck when a CS+ preceded grain and a CS− did not. In the first series of sessions, a tone was the CS+; in the second series, a clicking sound was the CS+. Control periods were silent. Pigeon 4117 (top panel) received response-independent grain after the CS+; the other birds received response-dependent grain after the CS+.

the response-independent grain procedure. These data are not shown. The data for the fourth pigeon, 4117, are in the top panel of Figure 1. The data for Pigeons 1664, 3659, and 5704 in the response-dependent grain procedure are also in Figure 1. Each pigeon eventually key pecked during a high percentage of CS+s, whether the tone or the clicking sound was the CS+; but they pecked during a low percentage of CS− and control periods.

Figure 2 shows key pecks per minute during the CS+, CS−, and control periods for the same pigeons and for the same procedures as Figure 1. The key-pecks-per-minute data show the same effects as the per-cent-periods-with-a-peck data: high rates of pecking in the CS+ and low rates in the CS− and control periods. The rate data, however, show a wider range.

## EXPERIMENT II

Experiment I demonstrated that pigeons key peck during auditory stimuli that precede the availability of grain. If such pecking was reinforced by rapid access to grain at the signal's offset, then an omission procedure should eliminate it. In Experiment II, key pecking during the signal omitted the availability of grain at the signal's off-set in a procedure similar to that used by Williams and Williams (1969). Williams and Williams lighted a response key (the negative key) just before response-independent grain, and found that pigeons that had been only magazine trained pecked the key on a high percentage of key illuminations, even though doing so prevented grain delivery. They also found that instead of pecking the negative key, pigeons pecked a second "irrelevant key" when it was illuminated at the same time as the negative key. For part of Experiment II, the top key was illuminated to determine if pecks would be directed toward it instead of toward the bottom key, where pecks would cancel grain availability.

### METHOD

*Subjects and Apparatus*

Six experimentally naive White Carneaux pigeons were obtained and maintained as in Experiment I.

With two exceptions, the apparatus was the same as in Experiment I. First, the clicking sound was not used; the CS was the tone. Second, for part of the time, the top key was illuminated white, and a peck on it produced a click from the relay mounted behind the front panel.

*Procedure*

All pigeons were exposed to several different procedures, presented to the birds in the following order.

*Key-peck training and extinction.* While the top key was dark, all pigeons were trained to peck the bottom key (continuously illuminated red) by the method of successive approximations. After the key peck was acquired, the pigeons were given one session consisting of 50 grain presentations delivered on a continuous reinforcement schedule. The next day, all key pecks were ineffective (extinction).

*Positive signal control.* This procedure, begun the day following extinction, was identical to the response-dependent grain procedure of Experiment I, except that no CS− was presented. A CS, the tone, was presented for 8 sec on a VT 90-sec schedule. One second after CS offset, a key peck produced 4 sec access to grain. Experimental sessions lasted about an hour and consisted of 35 CSs; all pigeons received at least 15 sessions.

*Negative signal control.* The 8-sec CS was presented 35 times per session on the VT 90-sec schedule. A key peck during the CS cancelled the availability of grain at CS offset.

*Irrelevant key.* Previous performances were reestablished under the positive signal-control procedure (10 to 14 sessions). The irrelevant-key procedure was identical to the negative signal-control procedure, except that the top key was continuously illuminated white, and a response on the top key produced a relay click but no other consequences.

## RESULTS

Figures 3 and 4 show per cent 8-sec CS and control periods with a peck and response rate during CS and control periods for Pigeons 3738 and 1993. These birds are representative of the others. Similar per-cent-periods-with-a-peck data for the other four pigeons are shown in Tables 1 and 2.

In the positive signal-control procedure, when administered for the first time, per cent CSs with a peck reached a high and stable level in two of four sessions. Per cent control periods with a peck started high but then declined to under 20%. The only exception was Pigeon 2076 (see Table 2); this bird pecked in fewer CS periods and more control periods than the others. When the positive procedure was reinstated following the negative signal-control procedure, per cent CSs with a peck increased to or surpassed previous levels.

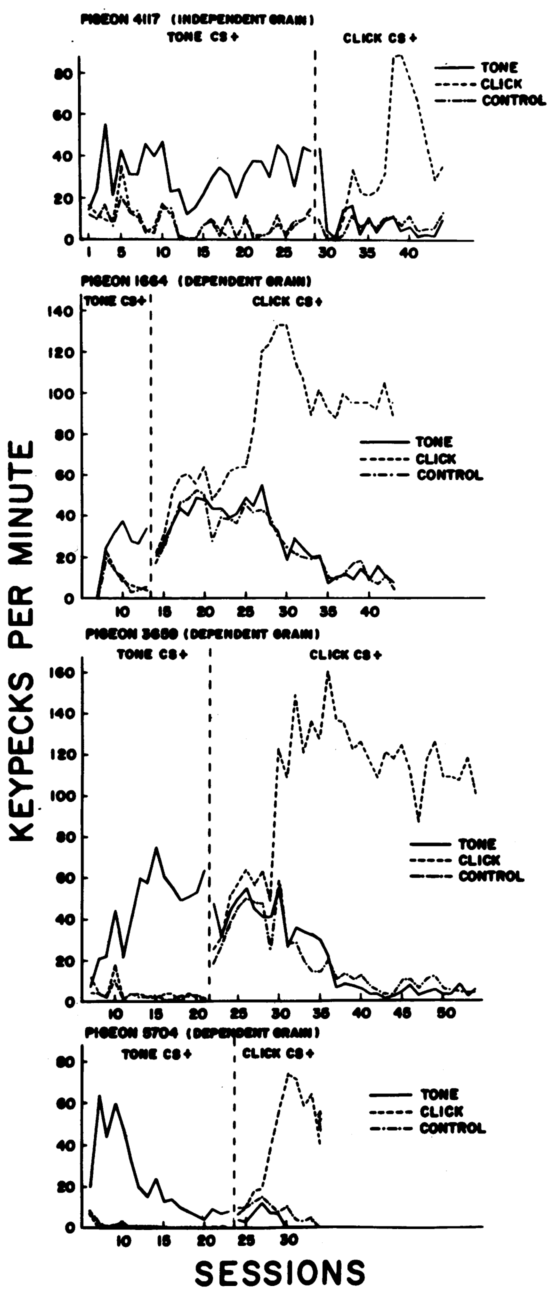


Fig. 2. Same as Figure 1, except that key pecks per minute is the dependent variable.

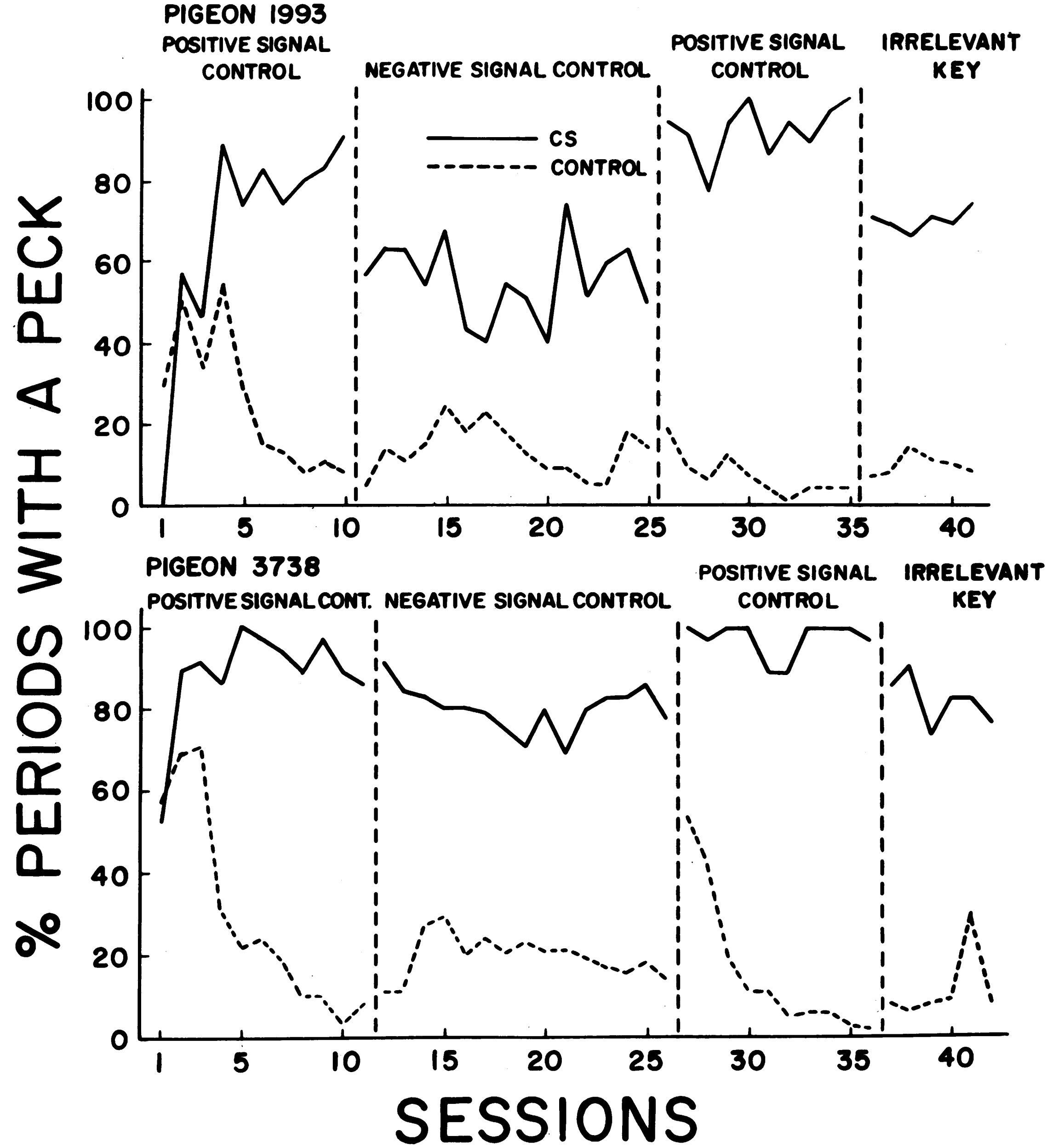


Fig. 3. Per cent periods with a peck when the CS preceded response-dependent grain. Control periods were silent. Grain was always available after the CS in the positive signal-control procedure. Grain was available only in the negative signal-control and irrelevant-key procedures if no response occurred during the CS. Responses on the irrelevant key are not shown (see text).

When the negative signal-control procedure was introduced, in which a response during the CS cancelled grain availability, per cent CSs with a peck declined for all birds except Pigeon 2076. This decline varied from only a few per cent, such as that for Pigeon 3738, to as much as 40% for Pigeon 1993. However, none of the pigeons stopped key pecking during the CS. Except for Pigeon 4277 in Session 22, the per cent CSs with a peck never fell below 40%.

In the irrelevant-key procedure, no pecks occurred at the irrelevant white key. The contingencies in the irrelevant-key procedure were the same as in the negative signal-control pro-

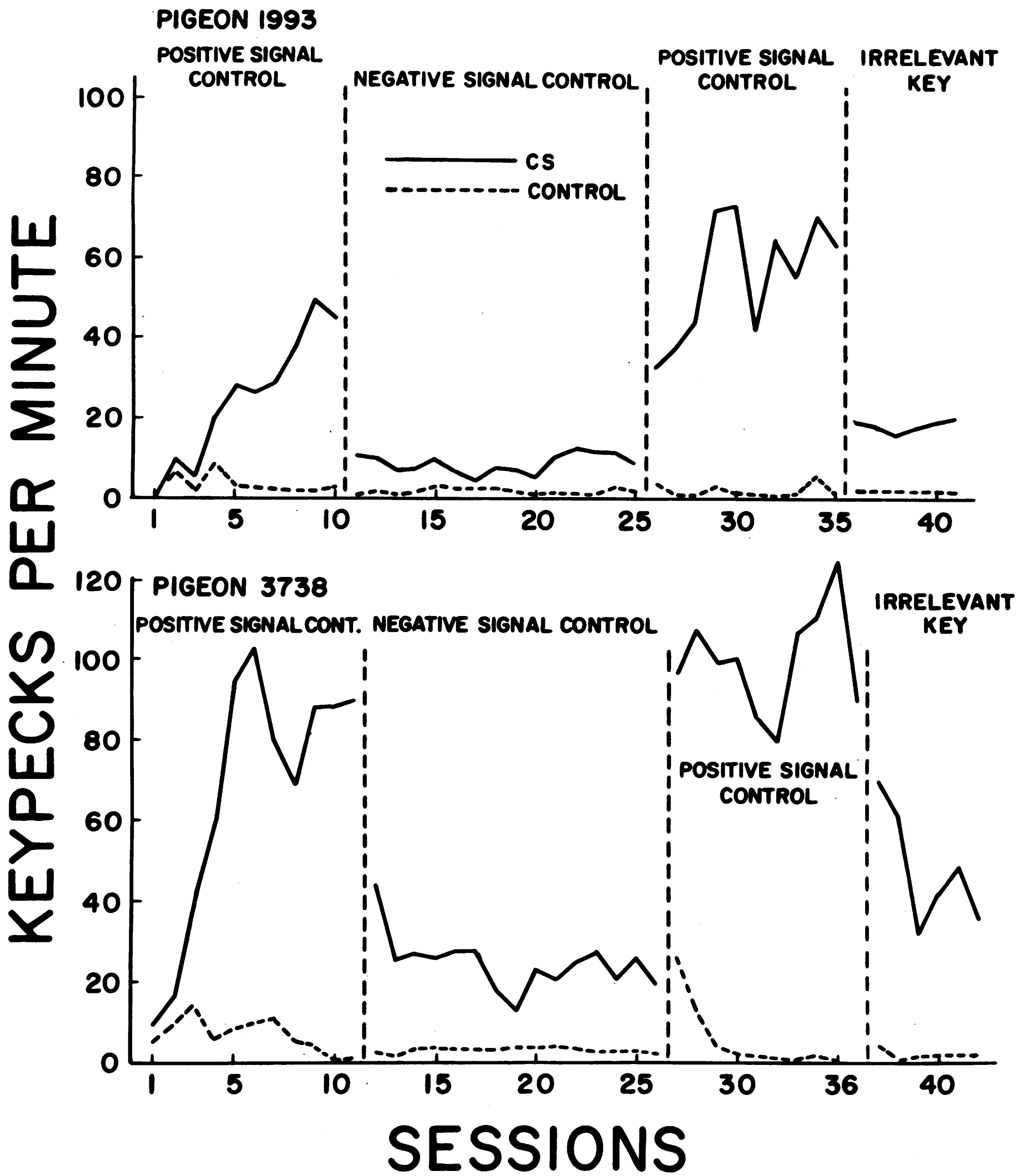


Fig. 4. Same as Figure 3, except that key pecks per minute is the dependent variable.

cedure, and the per-cent-periods-with-a-peck data were similar to the data for the negative procedure.

Response rates during CS and control periods paralleled the per cent periods with a peck. In general, response rates during the CS in the second presentation of each procedure (positive and irrelevant-negative) tended to be higher than in the first presentation of each procedure. An exception was Pigeon 2076, which responded at a low, steady rate during the CS in all procedures.

## EXPERIMENT III

To test the interpretation that CS offset acts as a conditioned reinforcer, pigeons in

Table 1

Per Cent CS and Control Periods with a Peck for Pigeons 4277 and 5758

*Positive Signal Control* — *Sessions*

| Pigeon and Period | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4277 | CS | 27 | 85 | 100 | 83 | 89 | 86 | 100 | 80 | 97 | 94 | | | |
| | Control | 41 | 75 | 77 | 31 | 25 | 20 | 12 | 11 | 10 | 8 | | | |
| 5758 | CS | 27 | 43 | 91 | 89 | 89 | 91 | 89 | 83 | 57 | 80 | 89 | 91 | 86 |
| | Control | 40 | 54 | 78 | 58 | 23 | 16 | 14 | 16 | 9 | 14 | 22 | 10 | 10 |

*Negative Signal Control* — *Sessions*

| Pigeon and Period | | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4277 | CS | 60 | 54 | 66 | 66 | 71 | 57 | 51 | 66 | 34 | 60 | 57 | 51 | 66 | 68 | 69 |
| | Control | 9 | 8 | 15 | 21 | 28 | 38 | 30 | 25 | 22 | 20 | 15 | 18 | 11 | 10 | 21 |
| 5758 | CS | 83 | 77 | 91 | 83 | 83 | 83 | 74 | 83 | 77 | 79 | 77 | 77 | 74 | 71 | 67 |
| | Control | 13 | 26 | 29 | 28 | 17 | 15 | 19 | 27 | 20 | 16 | 17 | 21 | 32 | 28 | 36 |

*Positive Signal Control* — *Sessions*

| Pigeon and Period | | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4277 | CS | 67 | 94 | 86 | 83 | 80 | 97 | 83 | 63 | 74 | 94 | 91 | 71 | 80 |
| | Control | 23 | 18 | 6 | 4 | 3 | 5 | 1 | 4 | 3 | 1 | 2 | 4 | 5 |
| 5758 | CS | 97 | 97 | 100 | 91 | 83 | 97 | 97 | 97 | 89 | 97 | | | |
| | Control | 46 | 21 | 22 | 8 | 6 | 11 | 8 | 4 | 4 | 7 | | | |

*Irrelevant Key* — *Sessions*

| Pigeon and Period | | 42 | 43 | 44 | 45 | 46 | 47 |
|---|---|---|---|---|---|---|---|
| 4277 | CS | 66 | 83 | 86 | 80 | 46 | 34 |
| | Control | 9 | 8 | 8 | 8 | 7 | 5 |
| 5758 | CS | 66 | 83 | 83 | 63 | 74 | 54 |
| | Control | 11 | 13 | 17 | 9 | 11 | 11 |



Table 2

Per Cent CS and Control Periods with a Peck for Pigeons 3031 and 2076

*Positive Signal Control* — *Sessions*

| Pigeon and Period | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3031 | CS | 20 | 74 | 86 | 83 | 83 | 77 | 60 | 80 | 86 | 86 | 80 | 83 | | | |
| | Control | 29 | 59 | 79 | 38 | 37 | 36 | 13 | 14 | 21 | 12 | 14 | 10 | | | |
| 2076 | CS | 39 | 49 | 0 | 40 | 43 | 57 | 63 | 60 | 31 | 71 | 77 | 57 | 63 | 51 | 60 |
| | Control | 58 | 58 | 0 | 68 | 35 | 22 | 18 | 21 | 18 | 38 | 26 | 25 | 19 | 5 | 7 |

*Negative Signal Control* — *Sessions*

| Pigeon and Period | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3031 | CS | 60 | 69 | 66 | 74 | 71 | 69 | 60 | 77 | 69 | 83 | 77 | 85 | 86 | 71 | 94 |
| | Control | 9 | 23 | 18 | 18 | 22 | 20 | 29 | 30 | 23 | 22 | 18 | 14 | 13 | 16 | 15 |
| 2076 | CS | 54 | 76 | 74 | 69 | 74 | 76 | 86 | 63 | 57 | 69 | 74 | 69 | 57 | 69 | 51 |
| | Control | 18 | 27 | 30 | 32 | 50 | 42 | 39 | 34 | 20 | 16 | 35 | 22 | 14 | 23 | 30 |

*Positive Signal Control* — *Sessions*

| Pigeon and Period | | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3031 | CS | 100 | 83 | 91 | 91 | 91 | 91 | 89 | 83 | 94 | 91 |
| | Control | 39 | 26 | 12 | 12 | 15 | 16 | 10 | 10 | 14 | 15 |
| 2076 | CS | 83 | 60 | 77 | 71 | 88 | 83 | 63 | 51 | 51 | 54 |
| | Control | 34 | 8 | 3 | 6 | 15 | 12 | 2 | 6 | 4 | 3 |

*Irrelevant key* — *Sessions*

| Pigeon and Period | | 41 | 42 | 43 | 44 | 45 | 46 |
|---|---|---|---|---|---|---|---|
| 3031 | CS | 80 | 83 | 92 | 91 | 83 | 86 |
| | Control | 16 | 12 | 15 | 11 | 13 | 11 |
| 2076 | CS | 66 | 72 | 83 | 63 | 80 | 80 |
| | Control | 13 | 16 | 21 | 22 | 20 | 19 |

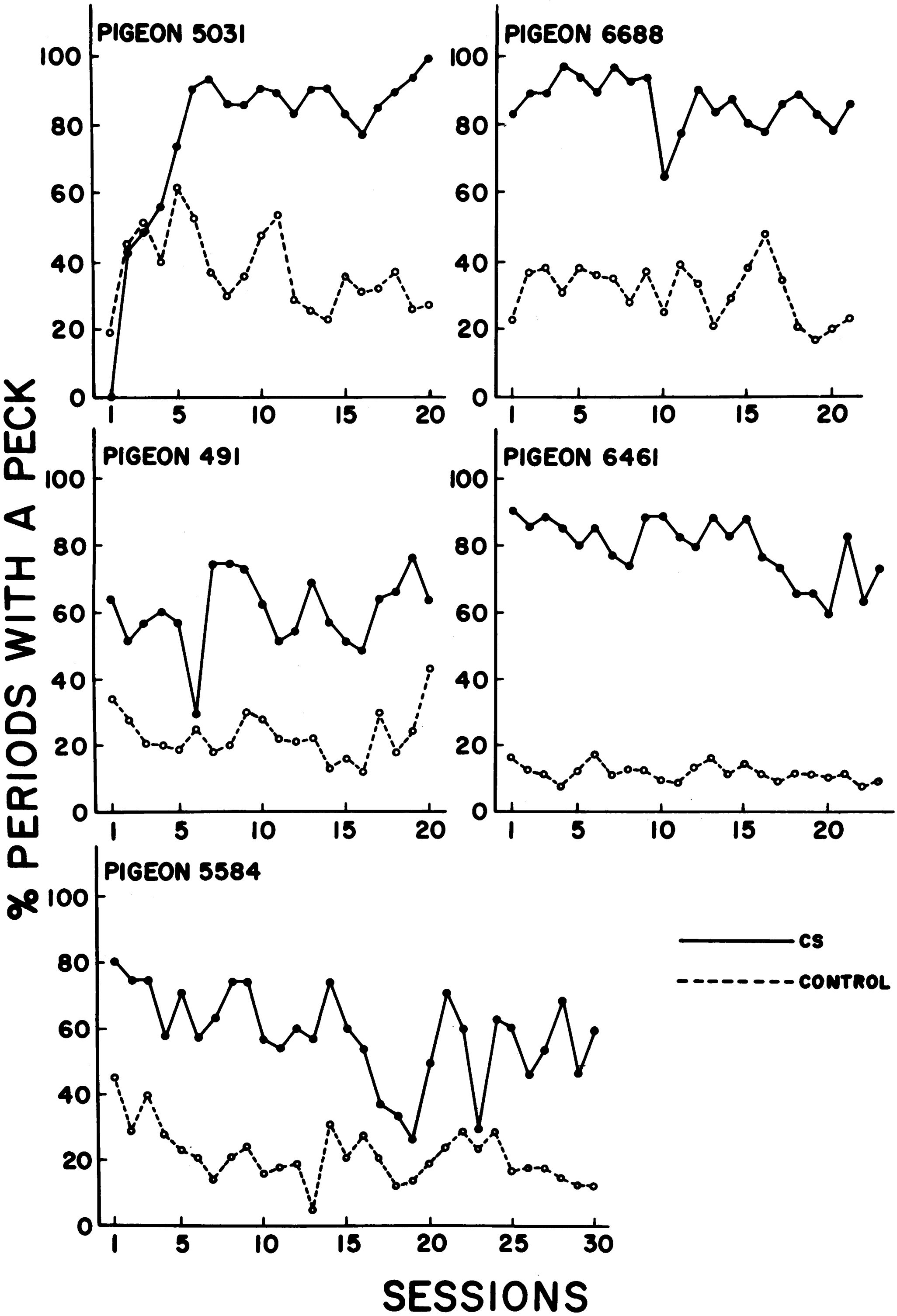


Fig. 5. Per cent periods with a peck when the CS preceded response-dependent grain. Control periods were silent. Grain was available only if no response occurred during the CS. The CS did not end until 2 sec had elapsed without a key peck.

Experiment III were exposed to a procedure similar to the negative signal-control procedure in Experiment II. The CS had a minimum duration of 8 sec; a key peck during the last 2 sec of the CS extended the CS 2 sec, as did each peck thereafter, such that the CS would not end until 2 sec had elapsed without a key peck.

## METHOD

### *Subjects and Apparatus*

Five White Carneaux pigeons were obtained and maintained as in Experiment I. Pigeon 5031 was experimentally naive. Pigeons 5584 and 6461 had previous experience with tones that signalled 1-min periods during which grain was available on a VI 10-sec schedule. These birds had been exposed to both positive and negative signal-control procedures in the signalled-VI experiment. Pigeons 6688 and 491 also had experience with tones signalling 1-min periods during which grain was delivered on various VI schedules, ranging from VI 5-sec to VI 90-sec. These birds had been exposed only to the positive signal-control procedure in the signalled-VI experiment.

Apparatus was the same as in Experiment II; the top key was dark and disconnected.

### *Procedure*

Pigeon 5031 was trained to peck the response key, while white, by the method of successive approximations. Following 100 reinforcers delivered on a continuous reinforcement schedule over two sessions, the experiment began. The other four pigeons began the experiment following signalled-VI procedures.

In this experiment, all five pigeons received the same procedure, a modification of the negative signal-control procedure of Experiment II. The CS, a tone, was presented for 8 sec on a VT 90-sec schedule. If no key peck occurred during the CS, response-dependent

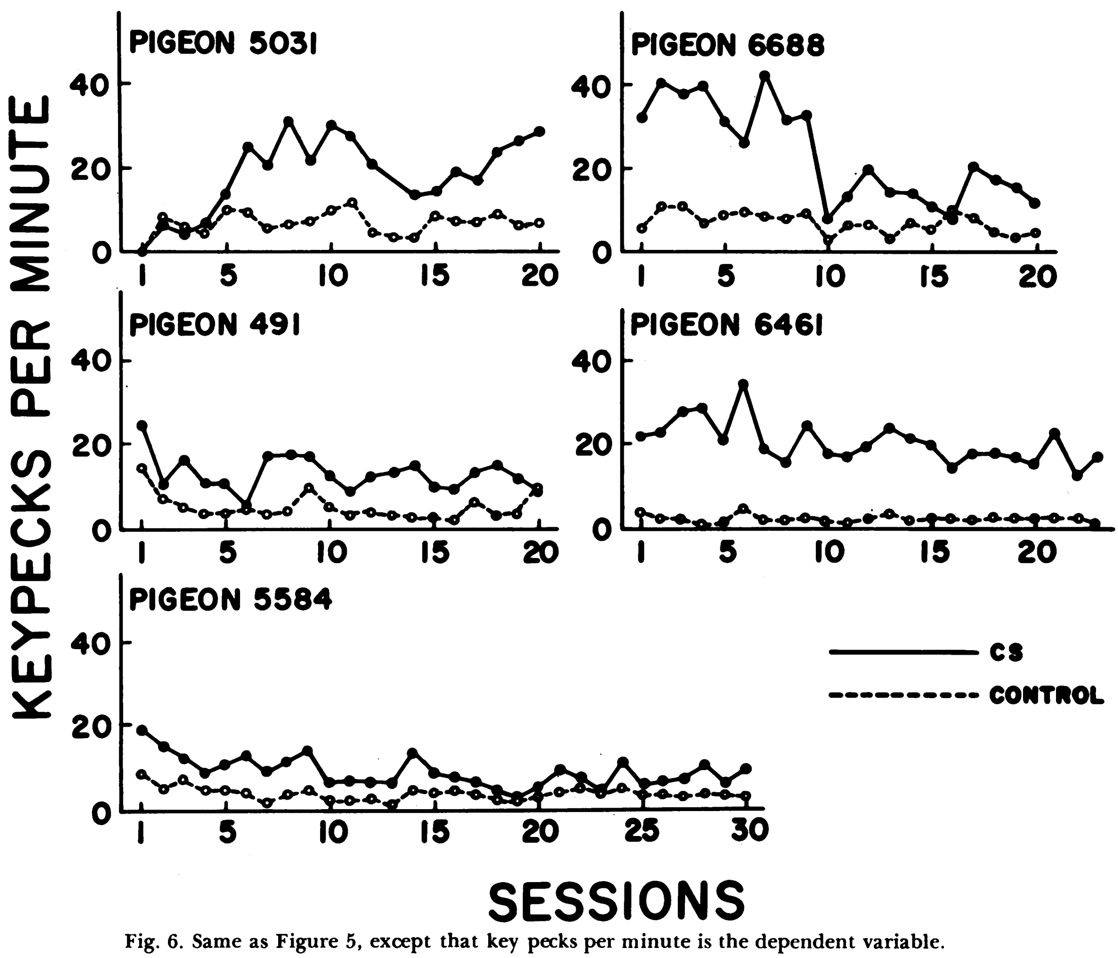


Fig. 6. Same as Figure 5, except that key pecks per minute is the dependent variable.

grain was available 1 sec after CS offset. A key peck during the CS cancelled grain availability at CS offset. If the pigeon key pecked during the last 2 sec of the CS, that key peck extended the CS for 2 sec from the key peck, as did each key peck thereafter. Hence, it was possible for the CS to be extended for a long time by continued pecking 2 sec before the CS was scheduled to end. The CS would not end until 2 sec had elapsed without a key peck.

Sessions lasted until 35 CSs had been presented (about 1 hr) and were usually conducted seven days per week. Pigeons were tested a minimum of 20 sessions.

### Results

Sessions were divided into 8-sec CS and control periods. Per cent CS and control periods with a peck for all pigeons are shown in Figure 5. Each bird pecked during a higher percentage of CS periods than control periods. Except for Pigeons 491 and 5584, per cent CS periods with a peck remained above 60% and often above 70%. Per cent control periods with a peck was below 40% and often below 30%.

Figure 6 shows response rate during CS and control periods for all pigeons. The response rate was higher during the CSs than during the control periods. Response rates during the CS were relatively stable for all birds except Pigeon 6688. This bird's rate decreased sharply in the tenth session and remained between 10 and 20 key pecks per minute. Pigeon 5031 showed a gradual increase in response rate over sessions.

Another index of responding during the CS is CS duration. The minimum CS duration for a session was about 4.5 min. Across the last five sessions for Pigeons 5584, 6461, 6688, 491, and 5031, the mean CS duration was 5.0 min, 5.0 min, 5.3 min, 5.2 min, and 5.0 min. These figures represent average increases in CS duration of 30 sec or more per session due to key pecking near the end of the CS.

## GENERAL DISCUSSION

Pigeons showed a strong tendency to key peck during an auditory stimulus preceding response-dependent grain; we refer to this behavior as signal-controlled responding. Experiment I showed that signal-controlled responding is not the result of pseudoconditioning, since pigeons key pecked only during a signal preceding grain and not during a signal that did not precede grain. Experiment II argued against an accidental-reinforcement interpretation, since key pecking during the CS occurred despite the fact that it cancelled grain at CS offset. Finally, Experiment III showed as inadequate a conditioned-reinforcement interpretation, since pigeons responded to delay CS offset.

The signal-controlled responding observed in the present experiments resembles automaintenance as reported by Brown and Jenkins (1968, Experiment IV) and Schwartz and Williams (1972, Experiment I). Automaintenance refers to key pecking generated and maintained using response-independent grain following a keylight CS. In the typical automaintenance experiment, a naive, magazine-trained pigeon is placed in a testing chamber. At various times throughout the session, the normally dark response key is illuminated for a few seconds, followed immediately by grain delivery. Key pecks during the keylight CS have no scheduled effect. In these experiments, responding is generated and maintained at high rates during the CS presentations. The primary procedural differences between the present and automaintenance procedures are the use in the present experiments of (1) a response-grain dependency, (2) preliminary key-peck training, and (3) a diffuse auditory signal. The primary behavioral difference is that the signal here controlled no key pecking in three of four birds without a response-grain dependency (but, see below). In the automaintenance procedure, pigeons peck during the signal with response-independent grain and without prior key-peck training.

The exception, Pigeon 4117, which did peck during the CS+ with response-independent grain, could have received accidental pairings of pecks with grain. Inspecting this pigeon's data closely, we noted that this pigeon pecked 10 times in the combined 1-sec intervals after the CS+s on the first day of testing, and no other bird pecked more than three times. On the second day of testing, Pigeon 4117 pecked 32 times in the combined 1-sec intervals following the CS+s, and the other pigeons emitted no key pecks in the 1-sec intervals following the CS+s. These data suggest that for even this pigeon, an accidental response-grain contingency may have led to the signal's control.

Auditory stimuli preceding grain generate pecking even in the absence of a response-grain dependency (Farthing, 1971). But without a response-grain dependency, pecking is not directed toward the key even if a lighted response key is present in the chamber (Bilbrey and Winokur, 1973; Schwartz, 1973). Since no pigeon pecked the irrelevant key in Experiment II, the above finding was confirmed. Further, pecking is not consistently directed at the source of the sound, but rather toward the feeder, floor, wall, or in the air (Farthing, 1971). This finding is consistent with Staddon and Simmelhag's (1971). These investigators delivered response-independent grain at varying intervals and observed that, just before grain delivery, all pigeons were emitting pecking activity, but that the pecks were not directed toward any particular aspect of the chamber. Some pigeons were pecking around the feeder, some at the wall, *etc.* It appears that the delivery of grain to pigeons generates pecking activity, and if the grain is preceded by a diffuse auditory signal, the signal comes to control the pecking behavior. But only if the grain is dependent on a key peck does the nonlocalized signal come to control key-pecking behavior.

The present experiments clearly favor an explanation based on the pairing of the signal (CS) with the reinforced response. Hence, signal-controlled responding may be an instance of Pavlovian conditioning. However, Pavlovian conditioning generally involves an unconditioned stimulus which, at the beginning, elicits the unconditioned response, such as food powder elicits salivation. If Pavlovian conditioning proves to be a satisfactory explanation of signal-controlled responding, then it is an instance of Pavlovian conditioning in which the unconditioned response is trained using operant reinforcement.

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